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Previous Research Analysis of the Traffic Network Study

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Abstract

Urban traffic network is a huge lifeline system. This article studied the traffic network analysis of the past which involved in complex network theory and aggregate traffic demand forecasting model theory, and proposed a number of unresolved difficulties.

Key words: traffic network; complex network; aggregate; traffic demand forecasting model

1. Background

Urban traffic network is a huge lifeline system. It builds on the geographical space, and is a transportation system based on two-dimensional Euclidean space. It consists of the physical road network and traffic demand network, in which roads can be abstracted as road connections, intersections can be abstracted as nodes, and lots of points and edges form the traffic network. If the road network is considered as the supply side, traffic demand network is considered as the demand side, then combine the travel behavior science of the demand side, to analyze the interaction between the supply and demand side and the supply efficiency of the road network is particularly important.

Previous researches about traffic network analysis usually have six methods [1], which are Geographic information system, Graph theory, Complex networks, Mathematical programming, Simulation, and Agent-based modeling. In comparison, the complex network theory as a new theory showed vitality, and has attracted the attention of many scholars.

It should be noted that, there are different views on using complex network theory to study the traffic network in today's academic [2], The opposition side think that the traffic network is small, its statistical properties are easily found and its characteristics are clear, and the traffic network is a two-dimensional

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plane network, its physical distance between the feature points is clear and the only fixed, thus can not apply complex network theory. But this paper argues that the traffic network can achieve complex and diverse functions, from the perspective of commitment to urban residents, the traffic network can be classified as social networks, from the perspective of traffic distribution, traffic network can be classified as a technology-based distribution network, and, even if only to examine the physical characteristics of the traffic network, the road network formation also has a technical network characteristics. Therefore, the traffic network is the carrier of variety functions and variety characteristics, and is a hybrid complex network.

2. Previous researches

2.1. Traffic network analysis based on complex network theory

Traffic network forms the city's backbone, and it is the carrier of urban social economics, and is the material basis of the urban transportation operation. And as the core process of urban construction, it is also considered as the key part of the urban operation. Porta et al [3] found that the six cities' road traffic network (1 square mile range) where had different urban patterns and historical backgrounds were scale-free network, and had a small world properties with the topology analysis. Montis et al [4] analyzed traffic network of Italy, and studied the correlation between traffic volume and network topology. Lammer [5] statistical analyzed more than 20 major cities of the German about their road network's topological, and found their traffic distribution had power-law characteristics, and then further explained the characteristics of the road grading. Crucitti, etc. [6] divided the cities into self-organization city and urban planning city, and then analyzed road traffic network using 4-betweenness neutral indicators, and then the result showed that self-organization city's road network had the nearly same scale-free property as the non-space network. Latora group [7] had done a lot of work in the study of urban infrastructure networks, and proposed using effectiveness concept to measure network efficiency. Jiang and C laramunt [8] topological structured and separated urban streets by zip code, and illustrated that the street network as the same had small-world network characteristics. Chowell et al [9] according to the large-scale simulation software TRANSIM simulated individual's traffic behavior in the virtual and directed traffic network, and found some power-law features on traffic network, and further analyzed the nonlinear relationship between indicators degree and traffic volume. Fujita and Suzuki [10] made the average distance between any of the two points as the basic indicator to look for the best structure of radial ring road network. kozuka and Kurita [11] [12] had comparative studied orthogonal grid-like road network and radial ring road network structure. Fu et al [13] studied highway passenger traffic network's scale-free characteristic and small-world effect based on the traffic frequency. Li Jiang and Qing-Sheng Guo [14] determined the overall hierarchy of the traffic network using the topology analysis method based on the GIS platform, and further analyzed the basic form of the traffic network.

2.2. traffic network analysis based on traffic demand forecasting

Traffic demand forecasting as the core content of traffic planning is the common means of traffic network structure analysis. People made unremitting efforts to forecast traffic demand effectively for a long time and finally developed large number of traffic demand forecasting model based on a variety of theory. Among them, the most widely used theory and model is undoubtedly the Trip-Based Four-Step Procedure which was developed in the 1950s. As the classical methods of traffic demand forecasting, its logic is clear, steps are distinct, and had been widely used in the actual project.

With the base of Trip-Based Four-Step Procedure, each stage also has its specific theory and corresponding model, among them the representative method are Fratar method, Furness method, entropy method, the shortest path heuristics method and traffic network equilibrium theory. In the 1970s, these theories become increasingly mature. However, with the extensive application of the theory and methods, the Trip-Based Four-Step Procedure increasing exposed to problem of their own, such as in the prediction process there are excessive need for data, takes too long, variable which reflecting the level of the traffic services uncoordinated, traffic area divided is impact by the subjective, and can not fully clearly reflect the effects of policy implementation.

So, in previous studies, destination choice probability which based on the Trip-Based Four-Step Procedure is usually displayed, "the closer the destinations, the higher the probability of being accessed, the more distant destinations, the lower the probability of being accessed". If to quantify the phenomenon with a model, which can be considered, firstly according to the transportation costs which are from origin to destination can build a utility function, and then can generate a destination choice model with random utility theory. But, for a model of the above, generally, must first solve two problems: ① how to determine the generalized transport costs, and how to determine the utility function; ② how to determine the unobservable error term's functional form of random utility theory. For the first question, the general believe that "the utility function is equal to the negative generalized transport costs, and the generalized transport costs will keep up the same proportional increase with the travel time", for the second question, the general practice is to assume "the error items of random utility are independent of each other, and obey the Gumbel distribution." Then build Multi-Logit model. The above process has implemented analysis object into the individual, and compared with the aggregate analysis of mean method it has got significant progress, so to a certain extent, it is appropriate. But the problem is the basic premise of Multi-Logit model which "the error terms of random utility theory are independent of each other, and obey Gumbel distribution" in some cases divorced from reality (such as the famous "red bus - blue bus" problem), and can not fully explain the traveler's destination choice behavior.

Based on the previous researches, the classical model considered the mechanism of traveler's destination choice is Wilson's entropy model [15]. Wilson's entropy model proposed three constraints, and as a prerequisite, solved trip distribution under the condition of maximum entropy. The three constraints refers to two situations, one is the amount of trip generation and the amount of trip attraction is a certain, the second is the total costs of transportation is a certain ("The amount of traffic area's trip generation is consistent with the established value" "The amount of traffic area's trip attraction is consistent with the established value" "Generalized transport costs is consistent with the established value") So through the condition of "traveler's generalized transport costs must be consistent with the established value", Wilson's entropy model elaborated the impact on the destination choice behavior influenced by generalized transport costs. That is, "If the generalized transport costs can be specified in some particular way, then the destination choice behavior which as the generalized transport costs the basis of decision-making will be described." The condition of transport costs is restricted by established value will for sure lead to the results of "people who go far will become less, people who go near will be more". In fact, the OD traffic volume expression from Wilson's entropy model has the same structure with gravity model.

In addition, scholar Anas [16] as the same with scholar Wilson, proposed the non-aggregate forms of Wilson's entropy model, with the equality constraints of trip generation · attraction and generalized transport costs. Anas' studies showed that the Multi-Logit model can be derived from the entropy model.

Anas and Wilson's contribution is that they put forward, as long as the traveler know in advance the actual generalized transport costs, then above the three constraints, can build a destination choice model under the condition of maximum entropy. But this paper argues that most of the trip is without prior information (or travel information is not sufficient), and it is very difficult to pre-determine the

generalized transport costs. Therefore, there are only two known conditions, traffic network structure and the departure point, those traveler actually costs are not a known condition.

In addition, Wilson and Anas's model, contains the deeper meaning of "under the condition of the limited available traffic resources, people generally tend to the places where will consume less resources ". This conclusion clarifies that the traditional traffic demand forecasting and planning methods which were developed prom the Trip-Based Four-Step Procedure is inadequate, because behavior initiates trip, and behavior is impacted by destination, travel time and so on, that means trips without purpose, trips with the consumption of resources unlimited is unreasonable. Because time is also a kind of resources and the time everyone can use every day is only 24 hours for a total, from 24 hours which can be assigned to trips is even quite limited. So under the condition of available distribution time is quite limited, we should discuss traveler's trip time distribution mechanism firstly, and model the distribution activities at the same time, and in order to instruct the transport network structure analysis, we should put forward destination choice model from a more objective perspective.

3. Conclusion

Although previous researches are different on its perspectives and focuses, they all reflected the following issues which are not resolved.

Firstly, previous studies have appraised traffic network with an average dimension, and it is a kind of aggregate analysis method. Aggregate analysis method assumes that the OD traffic volume of the study area is uniform, so the concept such as the average service level they proposed is in connection with all trips, the results are very rough, and there is no clear theoretical basis in traffic engineering area.

Secondly, previous researches usually described traffic network as topology, and carry out researches with the related indicator of graph theory or indicator such as degree distribution of the complex network theory, and there is less traffic network analysis with the consideration of travel behavior science. But basically, behavior initiates trip, behavior-based prediction methods can provide a theoretical and conceptual framework which are more convinced, because the most essential feature of the behavior model is the simulation analysis in accordance with people's behavior rules and ways of thinking (allow occasionally errors in travel decision-making process), and put the daily acts into the socio-economic environment and time constraints when carry out simulation analysis. Therefore, this paper believe that, in order to analyze traffic network structure effectively, generally we should define the evaluation perspective first, which means on which function to carry out evaluation to traffic network; and then it is more scientific to propose destination choice model which is behavior-based with the consideration of complex network theory, non- aggregate theory and travel behavior science.

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